

preferably used in the method of the present invention. The controller 70 uses the pressure and stroke readings to determine whether to increase or decrease injection pressure and fill rate to achieve a desired fill profile and pressure gradient. FIG. 9d illustrates an example of a pressure profile at the various pressure transducers for the present invention. Additionally the controller can be used to close valve gate 50 and to stop the flow of molten material into the cavity 22. The controller reduces the flow of molten material when the pressure at the end-of-fill point inside cavity 22 reaches a set point pressure. If valve gates are not utilized, the controller maintains a constant injection pressure until the material in the runner and mold cavity have solidified. When the pressure at the end-of-fill point inside cavity 22 reaches the set point pressure, the molten material is allowed to cool and solidify. Although the embodiment described above uses only one cavity, it is contemplated that multiple mold cavities maybe utilized to simultaneously carry out the method of the present invention.

FIG. 7 is a flowchart illustration of the injection molding process of the present invention. It will be understood that each step of the flowchart illustration can be implemented by computer program instructions or can be done manually. These computer program instructions may be loaded onto a computer or other programmable data processing apparatus to produce a machine, such that the instructions which execute on the computer or other programmable data processing apparatus create means for implementing the functions specified in the flowchart step. These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data

processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means which implement the function specified in the flowchart step. The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable data processing apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide steps for implementing the functions specified in the flowchart step.

It will be understood that each step of the flowchart illustration can be implemented by special purpose hardware-based computer systems which perform the specified functions or steps, or combinations of special purpose hardware and computer instructions, or can be done manually.

An injection molding machine utilizing an injection molding process for the present invention may have a single or multiple mold cavities. The process begins with step 100 by positioning the hard disc drive and or its component(s) into the mold cavities. The cavity is then injected with molten material using a resin feeding screw at a predetermined fill rate in step 110. The fill rate is monitored and controlled to maintain a desired viscosity. The time it takes to fill the cavity to the set-point pressure depends on the size of the cavity and the injection rate. In a preferred embodiment where a phase change material is molded around the surface of a voice coil motor, the injection rate is high. For example for overmolding a voice coil motor the injection rate is about $25 \text{ cm}^3/\text{sec}$

at its maximum and it takes about 0.2 seconds to fill the cavity to the set point pressure. In step 120, the pressure at the end-of-fill point inside the cavity is measured and compared to the set-point molding pressure. The set-point pressure is predetermined based on the size, shape and properties of the phase change material and the materials of the hard disc drive components. For injection molding a thermoplastic material on a voice coil motor for example, the set-point pressure is preferably about 3,500 PSI. The process goes back to step 110 if the pressure at the end-of-fill point inside the cavity is less than the set-point molding pressure. As the pressure inside the cavity approaches and reaches the set-point pressure, the injection pressure, commonly referred to as packing pressure, is reduced in step 130. Because of pressure drops across the runner and gate into the cavity, the injection pressure is usually much higher than the cavity pressure. After all of the cavities are full at the set-point pressure, a constant packing pressure is maintained and the molten material inside the cavities is allowed to cool and solidify in step 140. The injection molding process ends with step 150, when the components are ejected from the molding cavities.

By measuring the pressure at the end-of-fill point and holding the pressure inside the cavity at the set-point pressure, the phase change material will have more uniform density. Furthermore, the pressure gradient across the cavity is also more uniform and does not vary significantly. The phase change materials used to form the monolithic body are preferably plastics. Plastics are made of long polymer chain molecules which cause them to behave in a non-newtonian manner. As illustrated in FIG. 8, non-newtonian behavior with plastic materials is